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Effects of Introduced Trout on Aquatic Invertebrate Communities in High-Elevation Lakes of the Beartooth Plateau

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"Effects of Introduced Trout on Aquatic Invertebrate Communities in High-Elevation Lakes of the Beartooth Plateau"
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Effects of Introduced Trout on Aquatic Invertebrate Communities in High-Elevation Lakes of the Beartooth Plateau

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OBJECTIVES

The wilderness areas of western North America are known for their abundance of high-elevation lakes. Because of their elevation and inaccessibility, most of these lakes originally were fishless and supported stable populations of aquatic invertebrates and amphibians. However, non-native fish have been introduced to many of these lakes and much debate and controversy now centers on the social and biological aspects of fisheries management in wilderness areas, particularly with respect to impact on sensitive species. Management of sustained fisheries in high-elevation lakes is further complicated by the characteristic low productivity and low species diversity of these lakes. Even at low fish densities, the invertebrate populations in historically fishless lakes are often incapable of maintaining themselves after the introduction of the fish and invertebrate species important as fish food are completely eliminated.

Fish predation is especially severe in high elevation lakes due to the lack of cover and the paucity of alternate prey. In lowland lakes, zooplankton seek refuge from fish predators through diurnal vertical migration or the cover of littoral vegetation (e.g. Straskraba 1963, 1965, 1967; Postolkova 1967; Zaret & Suffern 1976; Wright et al., 1980; Zaret 1980), but these refuges are typically absent in high-elevation lakes. The importance of fish in regulating the size and structure of zooplankton communities has long been recognized. Adding fish to a previously fishless lake results in a zooplankton community dominated by small cladocerans and rotifers, while removing the fish can result in a community dominated by large cladocerans and few rotifers (Hrbacek 1958, 1961, 1962, 1965; Novotna & Hrbacek 1966). When fish are added to a lake with a plankton community characterized by large calanoid copepods and large cladocerans (mean size of 0.8 mm), the plankton community is altered to one characterized by a predominance of small cyclopoid copepods and small cladocerans (mean size 0.3 mm) and the absence of large copepods and cladocerans (Brooks & Dodson 1965).

A fisheries management plan was developed for the Absaroka-Beartooth Wilderness Area in 1980. Since that time, the Montana Department of Fish, Wildlife and Parks in Billings has maintained a computer data base on the lakes with fisheries, with information on stocking schedules, fish species composition, and fish population densities. However, while there is detailed information on the fish, there is little information on the food base which supports those fisheries. The only zooplankton data was collected in the late 1970's from lakes with fisheries. There is no information on zooplankton in the fishless lakes and no information on benthic invertebrates in either fishless lakes or lakes with fisheries.

The primary objective of this study is to sample and analyze the zooplankton communities in a number of fishless and fish-bearing lakes and compare and contrast these communities with respect to their species composition and abundance within and among lakes. The data collected during this one year study would provide the baseline information for developing a rigorous investigation into the effects of natural and introduced trout populations on the species composition of lake zooplankton communities and the structure of lake food webs. Furthermore, these investigations will shed light on the feasibility of managing these fisheries to minimize or even reverse these effects.

METHODS

Lake surveys were conducted during the summer of 1999 in an area of the Absaroka-Beartooth wilderness area where Columbia spotted frogs (*Rana luteiventris*) had been sited during field work in the summer of 1998 (Butler & Stiff, personal observations). A total of 17 lakes within a 5 mile square area of the Clarks Fork of the Yellowstone Rive drainage were sampled. Of these, seven have fish populations that are self-sustaining or maintained by stocking, while the remainder are fishless. Each lake was sampled from two sites, when possible, and two plankton tows were collected at each site and combined in a single sample bottle. Samples were collected over three sampling periods: July 21-22, July 28-29, and August 18-19.

Plankton samples were collected with a Wisconsin style horizontal sampler fitter with a fine mesh (86 µm) net. Samples were gathered via 10-m oblique transverse hauls cast from the shoreline. To prevent backwash effects, the net was drawn to the shore at approximately 1 m/s. Each 10 m haul sampled 103.9 liters of lake water. The samples were reduced to a volume of 50 ml, fixed immediately in the field using a 5% formalin solution, and transported to the laboratory. Plankters in each sample were identified and counted in the laboratory, using a Leica GZ6 compound microscope. Two replicates were counted for each sample.

In addition to the data collected and reported here, Aimee Wyrick collected fish, amphibian, and lake parameter data and those results have been presented in a separate report.

RESULTS

Species Diversity: Overall species diversity was quite low, as would be expected for oligotrophic montane and subalpine lakes. Among all the lakes sampled, a total of 5 species of Rotifera (*Keratella*, *Polyarthra*, *Kelicotia*, *Conochilus*, *Brachionus*), 6 species of Cladocera (*Polyphemus*, *Chydorus*, *Daphnia*, *Ceriodaphnia*, *Diaphanosomona*, *Bosmina*), and 3 species of Copepoda (*Cyclops* and 2 species of *Diaptomus*) were observed. Within lake diversity ranged from 2 species (Paddle and Production Lakes) to 10 species (Cliff Lake). There was no species unique to a single lake; all species were found in at least two of the lakes sampled. Diversity data cannot be compared with the plankton data of the Dept. of Fish, Wildlife, and Parks as they record only identify the large zooplankton (*Diaptomus* and *Daphnia*) and lump all other species together in the total number of zooplankton.

Plankton Density: Zooplankton density (measured as number of individuals per liter) was low, but within the range typical for oligotrophic montane and subalpine lakes. The minimum total zooplankton density recorded was less than one individual per liter and occurred in Moccasin Lake (on 7/21), Paddle Lake, and Pneumonia Lake. The greatest zooplankton density occurred in Cliff Lake, with approximately 200 individuals per liter recorded for site 1 on 8/18. For those lakes for which the DFWP has zooplankton data (Cliff, Moccasin, Little Moccasin, Production, Sliver, and Recruitment Lakes), their recorded densities were substantially lower than what was recorded in 1999. For example, in Cliff Lake (9/1978) the DFWP recorded plankton densities of 0.04/L, with *Diaptomus* (0.01/L) listed as the only large zooplankter. In contrast, in August 1999, we observed in Cliff Lake an average zooplankton density of 266 individuals per liter and two large zooplankters – *Diaptomus* (1.5/L) and *Daphnia* (27/L). Similarly, there was also a change in the presence and/or abundance of the large zooplankton species since the 1978/79 data collected by DFWP. For example, zooplankton data reported by the DFWP for Moccasin (8/1978), Production (8/1979), and Sliver (8/1978) did not indicate the presence of any large zooplankton species; however, for all three lakes both *Daphnia* and *Diaptomus* were present in 1999. Because the data available from the DFWP represent samples collected on a single date, it is not know whether these differences are significant, or simply an artifact of differences in sampling method or time of year.

Differences among dates: For those lakes sampled on multiple dates, there was a pronounced seasonal effect. With the exception of Kermit Lake, for all lakes sampled on multiple dates,

zooplankton densities in the samples collected on July 21 1999 were far less than those collected from the same lakes on later dates. For those lakes displaying this trend, the increase could be accounted for by the appearance in the later sampling dates large numbers of the colonial rotifer, *Conochilus*. Although this rotifer usually occurs in spherical colonies of as many as 30 or more individuals, the rotifers in the collected samples were isolated (single) individuals. I suspect that the large numbers of single individuals of this rotifer reflected the seasonal emergence of individuals from over-wintering eggs. Conversely, nauplii (the first instar stages of copepods) were most abundant in the July 21 samples, but were few or absent in samples collected later in the season. There was no consistent seasonal trend among any of the other zooplankton species identified; however, it is important to keep in mind that two sampling dates are insufficient for accurately determining the presence or absence of seasonal trends in zooplankton composition and abundance.

Differences among lakes: The most notable difference in zooplankton composition between those lakes with fish and those without was the great abundance of the colonial rotifer *Conochilus* in those lakes with fish. There, *Conochilus* accounted for as much as 99% of the total population (Sliver Lake), although usual values ranged between 70 and 95%. The data also suggest that there may be a stronger seasonal component to the density of large zooplankton (*Daphnia* and *Diaptomus*) in those lakes with fish, with maximum numbers in those samples collected on the first sampling date, compared to large zooplankton densities in lakes without fish. However, as mentioned above, two sampling dates are not sufficient for analyzing and comparing seasonal trends in community composition.

EXPLANATION OF DATA SHEETS

The upper set of numbers reflect the raw data counts (N), unaltered to account for dilution/concentration/count volume effects. The lower set of numbers reflect percent composition for each species, with total zooplankton density for each count presented in the lowermost row. Concentrated volume (V_S) represents the total (concentrated) volume of the sample. Count volume (V_C) represents the amount of the concentrated volume that was counted to yield the raw data. For all samples, the lake volume (V_L) sampled was 103.9 liters. The number of individuals per liter was calculated by the following equation: $\#/L = ((N(V_S / V_C))/ V_L)/2$

Pond Name	Cliff	Cliff	Cliff	Cliff	Cliff	Cliff	Finger	Finger	Finger	Finger	Kermit
Sampling Date	7/21/99	7/21/99	8/18/99	8/18/99	8/18/99	8/18/99	7/28/99	7/28/99	7/28/99	7/28/99	7/21/99
Lake Site			1	1	2	2	1	1	2	2	
Replicate	A	B	A	B	A	B	A	B	A	B	A
Concentrated Vol. (ml)	30	30	100	100	50	50	50	50	50	50	50
Count Vol. (ml)	5	5	2	2	5	5	5	5	5	5	5
Keratella			2		4	6			2		2
Polyarthra			4	2	1	4					
Kelicotia		1	82	46	234	262					
Conochilus			828	704	825	1053	886	1128	136	189	51
Brachionus											
Polyphemus			4	2					8	8	
Chydorus											2
Daphnia	42	34	14	4	50	40	14	38	11	10	67
Ceriodaphnia		1									
Diaphanosmona	17	19			5	8	2				25
Bosmina	1										
Nauplii	84	80		6	2	0	4	4			27
Diaptomus	32	27	8		17	10				1	27
Cyclops	10	19			1	1	2	12	2	3	75
TOTAL	186	181	942	764	1139	1384	908	1182	159	211	276
Keratella	0.0	0.0	0.2	0.0	0.4	0.4	0.0	0.0	1.3	0.0	0.7
Polyarthra	0.0	0.0	0.4	0.3	0.1	0.3	0.0	0.0	0.0	0.0	0.0
Kelicotia	0.0	0.6	8.7	6.0	20.5	18.9	0.0	0.0	0.0	0.0	0.0
Conochilus	0.0	0.0	87.9	92.1	72.4	76.1	97.6	95.4	85.5	89.6	18.5
Brachionus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Polyphemus	0.0	0.0	0.4	0.3	0.0	0.0	0.0	0.0	5.0	3.8	0.0
Chydorus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Daphnia	22.6	18.8	1.5	0.5	4.4	2.9	1.5	3.2	6.9	4.7	24.3
Ceriodaphnia	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diaphanosmona	9.1	10.5	0.0	0.0	0.4	0.6	0.2	0.0	0.0	0.0	9.1
Bosmina	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nauplii	45.2	44.2	0.0	0.8	0.2	0.0	0.4	0.3	0.0	0.0	9.8
Diaptomus	17.2	14.9	0.8	0.0	1.5	0.7	0.0	0.0	0.0	0.5	9.8
Cyclops	5.4	10.5	0.0	0.0	0.1	0.1	0.2	1.0	1.3	1.4	27.2
#/L	5.37	5.23	226.66	183.83	54.81	66.60	43.70	56.88	7.65	10.15	13.28

Kermit	Kermit	Kermit	L. Moc.	L. Moc.	L. Moc.	L. Moc.	L. Washtub	L. Washtub	Mocassin	Mocassin	Mocassin	Mocassin
7/21/99	8/17/99	8/17/99	7/21/99	7/21/99	8/17/99	8/17/99	8/17/99	8/17/99	7/21/99	7/21/99	8/17/99	8/17/99
											1	1
B	A	B	A	B	A	B	A	B	A	B	A	B
50	50	50	80	80	50	50	30	30	50	50	50	50
5	5	5	5	5	2	2	5	1	5	5	5	5
1	1	1										
							304	66			11	17
72	1	1	224	242	764	924	312	63			489	500
					1							
4			6	7					3			
65	259	304	1	3	21	36	82	23	1	1	4	3
10			1	1							21	10
							3					
18	2	1	18	12			6	1	6	7	6	4
14	68	72			11	4	55	15			19	15
81	9	1	4	3			4		11	8	21	24
265	340	380	254	268	797	964	766	168	21	16	571	573
0.4	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	39.7	39.3	0.0	0.0	1.9	3.0
27.2	0.3	0.3	88.2	90.3	95.9	95.9	40.7	37.5	0.0	0.0	85.6	87.3
0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.5	0.0	0.0	2.4	2.6	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0
24.5	76.2	80.0	0.4	1.1	2.6	3.7	10.7	13.7	4.8	6.3	0.7	0.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.8	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	3.7	1.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
6.8	0.6	0.3	7.1	4.5	0.0	0.0	0.8	0.6	28.6	43.8	1.1	0.7
5.3	20.0	18.9	0.0	0.0	1.4	0.4	7.2	8.9	0.0	0.0	3.3	2.6
30.6	2.6	0.3	1.6	1.1	0.0	0.0	0.5	0.0	52.4	50.0	3.7	4.2
12.75	16.36	18.29	19.56	20.64	95.89	115.98	22.12	24.25	1.01	0.77	27.48	27.57

Mocassin	Mocassin	Peanut	Peanut	Peanut	Peanut	Pneumonia	Pneumonia	Production	Production	Puddle	Puddle	Recruit.
8/17/99	8/17/99	7/21/99	7/21/99	8/17/99	8/17/99	7/29/99	7/29/99	7/29/99	7/29/99	7/29/99	7/29/99	7/29/99
2	2											1
A	B	A	B	A	B	A	B	A	B	A	B	A
50	50	30	30	50	50	30	30	30	30	25	25	25
5	5	5	5	5	5	5	5	5	5	5	5	5
			3	10	6							
5	7	2	3	1	1	2	2					1
66	31	23	32	329	243	4	2	1		1	1	46
4	6											
			1									
		13	5	35	24	9	9	33	41	7	6	20
		2										
24	24	7	1									4
												1
4	2	43	23	2	1							
		5	6	10	36	1	1	6	2	7	3	2
9	10		2							1		
112	80	95	76	387	311	16	14	40	43	16	10	74
0.0	0.0	0.0	3.9	2.6	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.5	8.8	2.1	3.9	0.3	0.3	12.5	14.3	0.0	0.0	0.0	0.0	1.4
58.9	38.8	24.2	42.1	85.0	78.1	25.0	14.3	2.5	0.0	6.3	10.0	62.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.6	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	13.7	6.6	9.0	7.7	56.3	64.3	82.5	95.3	43.8	60.0	27.0
0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.4	30.0	7.4	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.4
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4
3.6	2.5	45.3	30.3	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	5.3	7.9	2.6	11.6	6.3	7.1	15.0	4.7	43.8	30.0	2.7
8.0	12.5	0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0
5.39	3.85	2.74	2.19	18.62	14.97	0.46	0.40	1.15	1.24	0.38	0.24	1.78

Recruit.	Recruit.	Recruit.	Sliver	Sliver	Splinter	Splinter	Splinter	Splinter	Stash	Stash	Stash	Stash
7/29/99	7/29/99	7/29/99	7/21/99	7/21/99	7/30/99	7/30/99	7/30/99	7/30/99	7/29/99	7/29/99	7/29/99	7/29/99
1	2	2			1	1	2	2	1	1	2	2
B	A	B	A	B	A	B	A	B	A	B	A	B
25	50	50	30	30	50	50	50	50	25	25	50	50
5	5	5	5	5	5	1	2	2	5	5	5	5
									1	1		
				1								
53	22	26	36	58	1206	204	225	197	120	185	536	494
	1											
					12	1					2	6
17	9	10	3	5	36		4	2	19	20	10	6
3					4				1	1		
1											1	
1			7	6	2					3	1	
4	2		2									
	1			3	6	1	2		6	4	1	4
79	35	36	48	73	1266	206	231	199	147	214	551	510
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.5	0.0	0.0
0.0	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
67.1	62.9	72.2	75.0	79.5	95.3	99.0	97.4	99.0	81.6	86.4	97.3	96.9
0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.9	0.5	0.0	0.0	0.0	0.0	0.4	1.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21.5	25.7	27.8	6.3	6.8	2.8	0.0	1.7	1.0	12.9	9.3	1.8	1.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.8	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.7	0.5	0.0	0.0
1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
1.3	0.0	0.0	14.6	8.2	0.2	0.0	0.0	0.0	0.0	1.4	0.2	0.0
5.1	5.7	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.9	0.0	0.0	4.1	0.5	0.5	0.9	0.0	4.1	1.9	0.2	0.8
1.90	1.68	1.73	1.39	2.11	60.92	49.57	27.79	23.94	3.54	5.15	26.52	24.54

Unnamed	Unnamed	Weasel	Weasel
7/29/99	7/29/99	7/29/99	7/29/99
A	B	A	B
30	30	25	25
5	5	5	5
1	2		
	1		
204	194	218	224
			2
12	18	7	3
6	2		
2		3	2
			1
1	3	1	1
9	6		2
235	226	229	235
0.0	0.0	0.0	0.0
0.4	0.9	0.0	0.0
0.0	0.4	0.0	0.0
86.8	85.8	95.2	95.3
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.9
0.0	0.0	0.0	0.0
5.1	8.0	3.1	1.3
2.6	0.9	0.0	0.0
0.9	0.0	1.3	0.9
0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.4
0.4	1.3	0.4	0.4
3.8	2.7	0.0	0.9
6.79	6.53	5.51	5.65